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Function description

1 General

The Babytherm 8000 is a modular system for providing:

- Heat therapy
- Oxygen and aerosol therapy
- Reanimation
- Intensive care for premature babies, new-born babies and infants.

2 Mechanical system

2.1 Trolley

The Babytherm 8000 is available with various trolleys:

Units with no electrical height adjustment:

Small base plate for heated cot

Large base plate for intensive-care model or reanimation unit. This version permits installation of a radiant heater.

Units with electrical height adjustment

Small trolley for heated cot

Large trolley for intensive-care module or reanimation unit. This version permits installation of a radiant heater.

2.2 Base plate for resting surface

The resting surface is attached to the base plate. The Babytherm 8000 is available with various base plates:

- Small base plate and small trolley for heated cot.
- Large base plate and large trolley for intensive-care model or reanimation unit. This version permits installation of a radiant heater

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2.3 Socket strip

Caution: The 3x socket strip beneath the base plate of the resting surface is only intended for:

- Babytherm mattress heating
- Dräger radiant heater 600W
- Babytherm height adjustment

Other loads are not permitted!

Electrical safety is checked by way of the common power cord.

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2.4 Resting surface

The resting-surface assembly is made up of the following:

- Resting surface
- Tilt-mechanism bottom section, bolted to base plate
- Mechanical system for tilt mechanism
- 4 corners for holding glass

Various side panels can be attached to the resting surface:

- 23 cm high side panels for heated cot or
- 15 cm deep side panels for reanimation unit

The resting surface comes with (heated cot and without reanimation unit) mattress heating:

With mattress heating:

- Gel mattress 2M 20 827

The mattress heating panel is only intended for the gel mattress 2M 20 827!

Danger:

The gel mattress 2M 20 827 may only be used in the Babytherm 8000 if resting-surface heating has been fitted!

The gel mattress 2M 20 827 is not to be used in the Babytherm 4200 or in other heated cots with a heating-panel temperature in excess of 40 °C danger of burns!

Keep sharp objects away from gel mattress danger of damage!

Without mattress heating:

- Foam mattress 2M 21 012
- Openings which are not needed are sealed with dummy plugs.

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2.4.1 Tilt mechanism for resting surface

The bottom section of the resting-surface tilt mechanism is connected to the base plate by means of 4 hexagon socket-head bolts. The resting surface is positioned in this section and is supported on one side by rollers and on the other by teflon strips as anti-friction bearings. The resting surface is fixed by means of gear teeth in the bottom section and the mechanical-system latch of the resting-surface tilt mechanism.

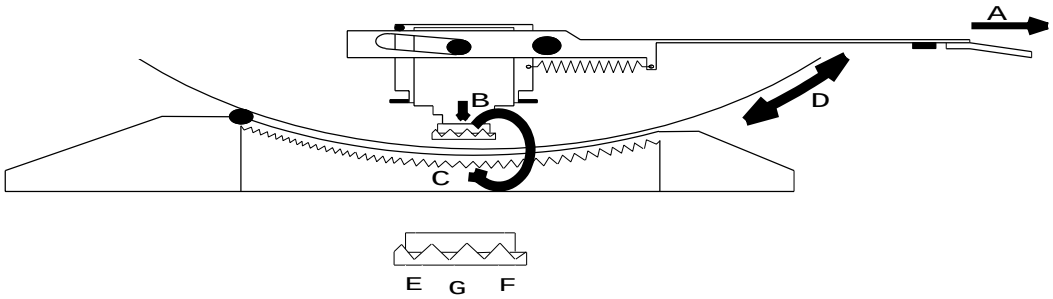

Fig. 1: Tilt mechanism for resting surface

Pulling the lever **A** presses the latch **B** downwards out of the gear teeth **C** and the resting surface **D** can be swivelled +15° to -20° out of the basic position. The lever is pulled back again in each case by 2 springs and the resting surface thus fixed in position.

2.4.2 Pneumatic system (extraction)

Two extractors are provided for the Babytherm 8000:

- Extractor -0.9 bar 2M 85 040
- Extractor -0.5 bar 2M 85 045

The infinite vacuum is generated by an ejector. The extractor is supplied by way of the O2 or compressed-air system. All plastic parts subject to contamination can be sterilised in an autoclave at temperatures up to 134 °C.

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3 Mattress heating

3.1 Resting-surface heating concept

The heated cot and OC versions feature a new resting-surface heater. The heating system is made up of the following components:

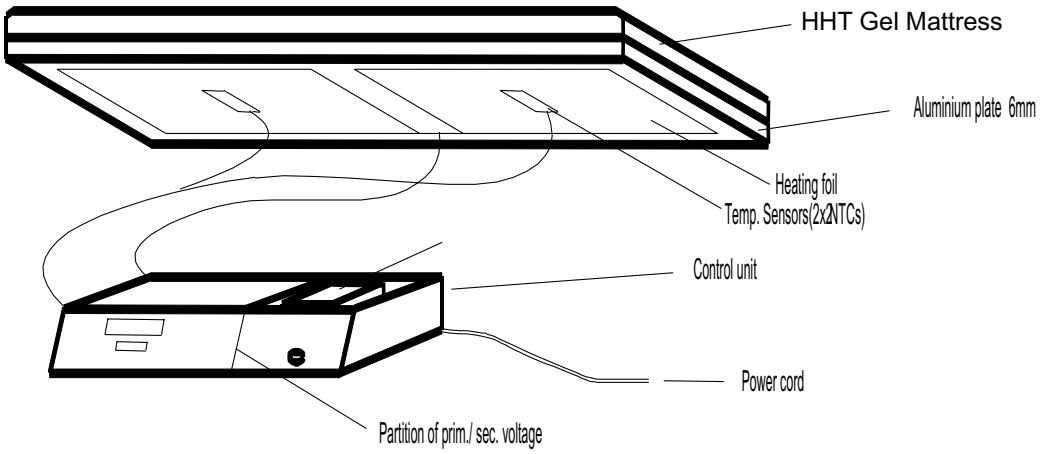

Fig. 2: Heating system

3.1.1 Mattress

The mattress consists of a thermally conductive gel (HHT = high heat transfer).

Danger:

This gel mattress is not to be used in the Babytherm 4200!

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3.1.2 Heating panel

The heating panel is inserted from above into the resting surface and secured with 4 screws. An all-round seal prevents the ingress of dirt and moisture. The heating panel is made of a backing plate (6 mm aluminium) with bonded -on heating foil 24V/120W and 2 bolted-on twin temperature sensors.

3.1.3 Control unit

This unit is secured in position in the resting-surface housing with 2 slide locks.

The control unit is made up of the following components:

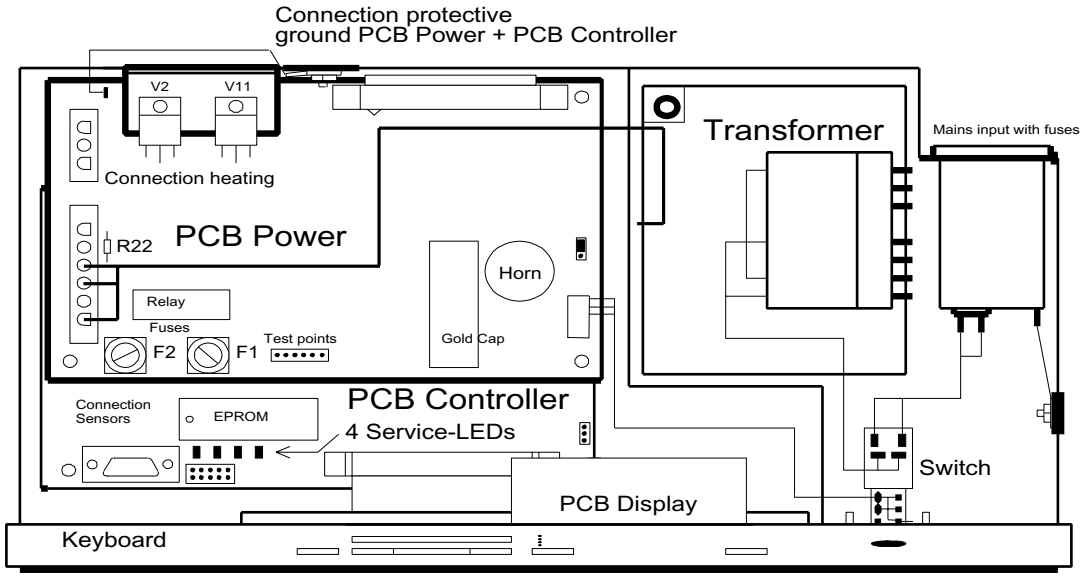

Fig. 3: Control unit

- Touch-sensitive keys with LEDs
- Transformer with 4KV isolation
- Controller PCB (P 68332, EPROM, I/Os, AD conversion ...)
- Power PCB (actuation of heating, voltage regulator ...)
- Display PCB (7-segment displays with actuation, keypad interrogation)
- Accessory set for voltage version (adapter 100-127 V and other fuse links in mains input)

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3.1.4 Block diagram of mattress heating

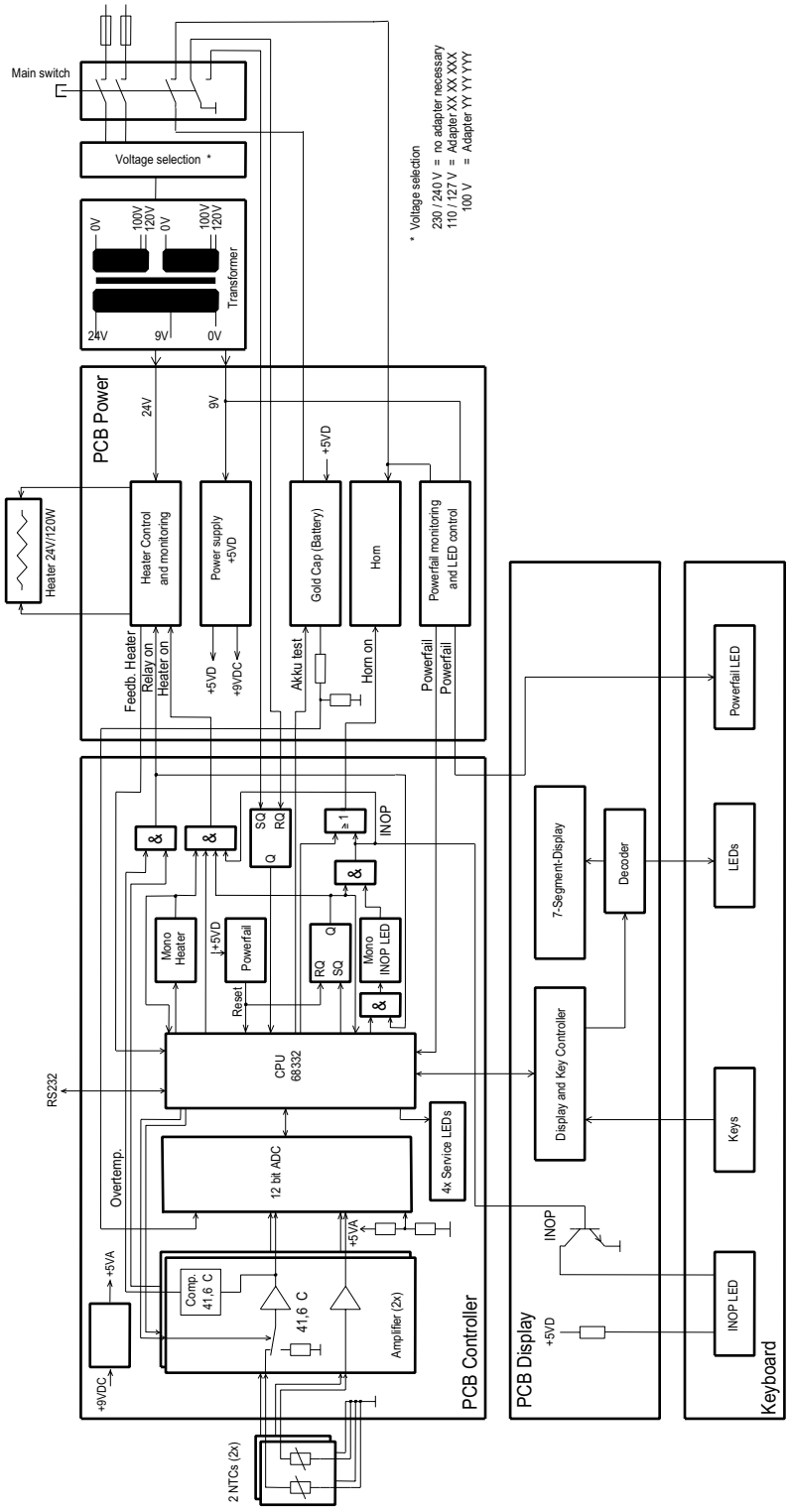

Fig. 4: Block diagram of mattress heating

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3.2 Functional description and software specifications

3.2.1 Front panel

The front panel contains the following components:

Touch-sensitive keys

- Range expansion
- Positive setpoint temperature and negative setpoint temperature. The setpoint can be adjusted in 0.1 °C increments: 35.0 °C - 37.0 °C (standard range without expansion) or 30.0 °C - 38.5 °C (with range expansion)
- 15 min. suppression for active alarms
- "Check" key for testing display elements and horn

Mains on/off switch

7-segment displays

- 3-digit display for measured value. Display range 5 °C - 45 °C.
- 3-digit display for setpoint. 35.0 °C - 37.0 °C (standard range without expansion) or 30.0 °C - 38.5 °C (with range expansion)

LEDs

- Range expansion on (in range expansion key)
- Alarm tone suppression on (in alarm tone suppression key)
- Excess temperature
- Desired/actual-value difference 1.0 °C
- Power failure
- Heating status optional: A heating LED can be called up as decimal point by jointly pressing for 5s the positive and negative setpoint keys in the 7-segment display of the setpoint display. The display is generated from the heating check-back signal.

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3.2.2 Measurement of mattress temperature

The temperatures are measured at two different locations on the heating panel. The higher temperature in each case is displayed:

T Mattress = T Display = T Meas. - T Offset

T Offset = 1.0 °C over entire measuring range

A second temperature sensor in each case at the measurement location supplies redundant measured values. A sensor warning is given in the case of a deviation of more than 0.5 °C at a measurement point.

To avoid temperatures which could endanger patients, a processor-independent deactivation path ensures that the maximum heating-panel temperature of 42 °C is not exceeded.

3.2.3 Alarms

The mattress heating features a graded warning system. Faults detected are reported in line with their significance.

A setpoint deviation results in an intermittent alarm tone which can be acoustically suppressed for 15 minutes by way of the "alarm suppression" key. All other faults lead to a continuous alarm tone which cannot be suppressed. Corresponding alarm LEDs or the measured value display flash(es) with all alarms.

Setpoint deviation alarm

- Measured value display flashes
- Appropriate alarm LED flashes
- Intermittent alarm tone (can be suppressed for 15 minutes)

The alarm tone for inadequate mattress temperature is suppressed automatically following cold start for a maximum of one hour. If the value is more than 1.0 °C below the setpoint during this period, the alarm is displayed during the suppression period by the corresponding LED; the measured value display does not flash and the horn is not active.

The warning suppression time is prematurely cancelled if the measured value is not more than 1.0 °C below the setpoint.

The LED "alarm tone suppression" lights continuously if acoustic alarms have been suppressed.

If a further alarm situation arises during the alarm tone suppression time, the acoustic warning is reactivated and the alarm tone suppression period cancelled.

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Excess temperature alarm 40.0 °C

- Measured value display flashes
- Appropriate alarm LED flashes
- Continuous horn tone cannot be suppressed
- Heating off

The alarm is automatically retracted if the displayed value is 0.5 °C over the setpoint.

Safety shutdown 42 °C

If a heating panel temperature of 42.0 °C is reached, the heating is automatically shut down via a processor-independent deactivation path employing a safety relay.

- Measured value display flashes
- Appropriate alarm LED flashes
- INOP LED lights
- Continuous horn tone cannot be deactivated

This alarm can only be reset with the on/off switch.

Sensor alarm

Faults in the temperature sensors or in the sensing procedure in the following alarm message:

- The three centre segments flash in the measured value display
- Continuous horn tone cannot be deactivated
- Heating off

INOP

Serious hardware or software errors, which make operation impossible for technical or safety reasons, lead to total failure of the mattress heating. The independent shut-down path ensures that the heating is always deactivated. The following alarm message is given:

- INOP LED lights
- Continuous horn tone cannot be deactivated
- Where technically possible, the current measured value flashes on the display

The unit is inoperative.

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3.2.4 Software safety features

All errors detected in the course of the tests described below produce an INOP error message.

RAM test

The address area of the RAM is tested in the time period between switch-on and bootstrapping of the operating system.

EEPROM test

The EEPROM is checked following switch-on of the unit by interrogating one test cell. The test cells are then rewritten and compared to the reference pattern again if there is a lack of coincidence with the reference pattern. An INOP alarm is triggered if the reference pattern can still not be read back.

ROM test

After switching on the unit, the ROM contents is checked by way of signature formation (CRC). ROM tests are executed cyclically during operation.

Watchdog tests

The run time of the two watchdogs is checked by way of a software counter.

Display driver test

The internal RAM of the keypad and display module 82C79 is read back immediately after display writing and compared to the data request.

Logic monitoring of program run

The function of tasks relevant to safety are checked logically by a monitoring task.

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10-minute test

The 10-minute test is a routine in which the function of all testable hardware safety features is checked at intervals of 10 minutes:

- Excess temperature comparator and independent shutdown path for heating
- Accuracy of mattress-temperature sensor circuit
- A/D converter and multiplexer
- Heating watchdog
- Analog +5 V voltage monitoring

Switch-on test

Switch on unit:

- All displays and horn are actuated for approx. 2 s

A self-test which checks the function of the processor and its peripherals is implemented during this period.

Following completion of the self-test, a setpoint of 37.0 °C is indicated with the measured value and the label "SEt" being alternately presented on the measured value display. The "SEt" display is a prompt for adjusting or acknowledging the setpoint.

The first ten minute test is implemented after the self-test as can be heard from the safety relay switching.

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3.3 Mattress heating electronics

3.3.1 Design and general overview

Integration of electronics in housing

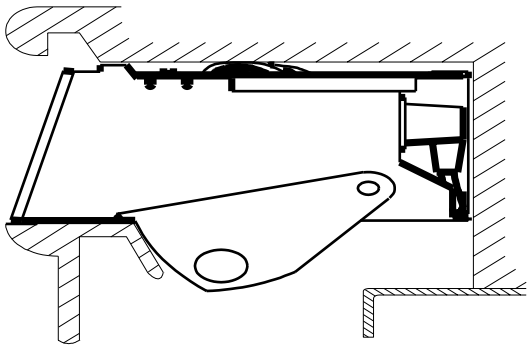

Fig. 5: Electronic module

The electronics module is held in place in the opening in the housing by two locks on the side. The mains input is located on the back with the connectors for the sensors and the heating being provided on the cover.

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Mechanical integration of electronic components into electronics module

In the illustration below the keypad with the display PCB has been tilted forwards and the power PCB (which is above the controller PCB in the installed condition) swivelled out:

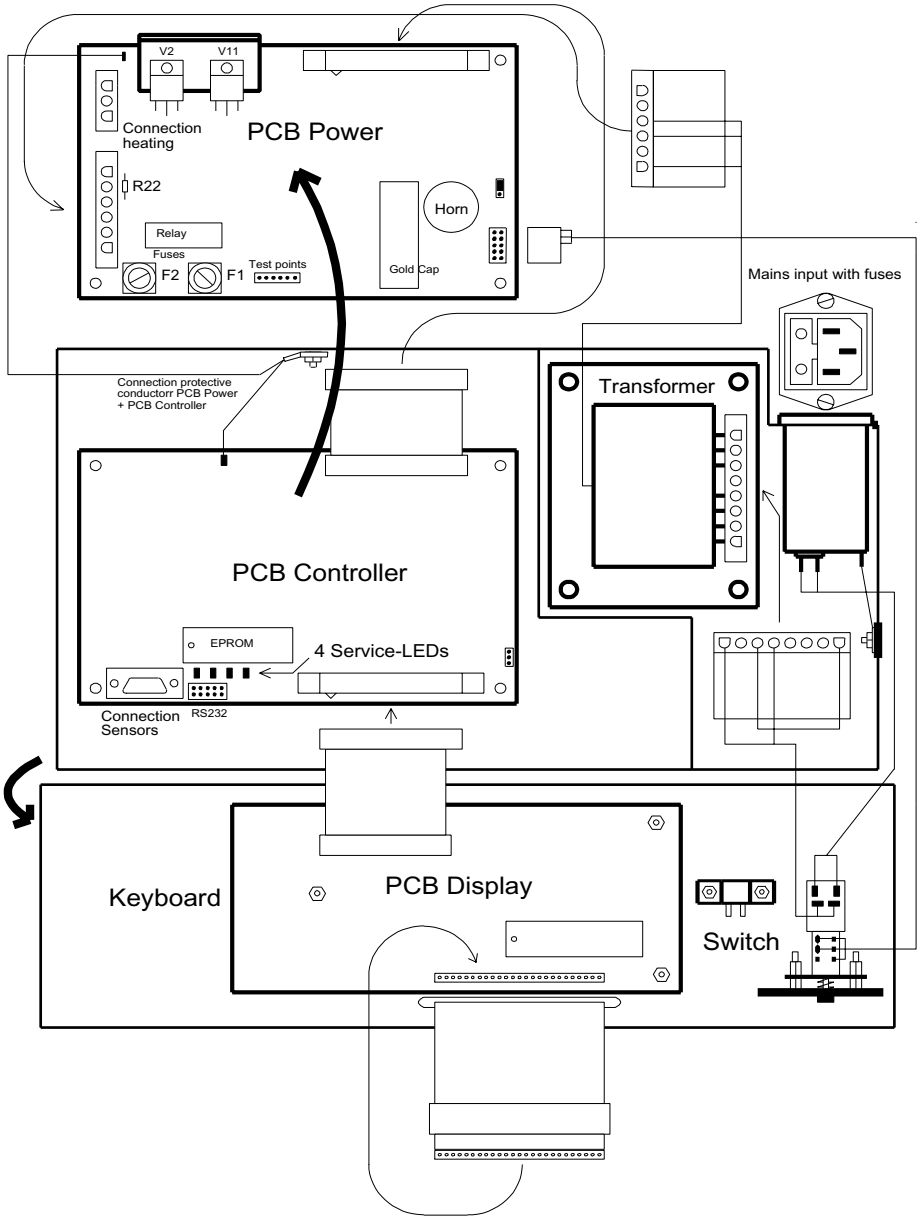

Fig. 6: Electronic components

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3.3.2 Block diagram of mattress heating

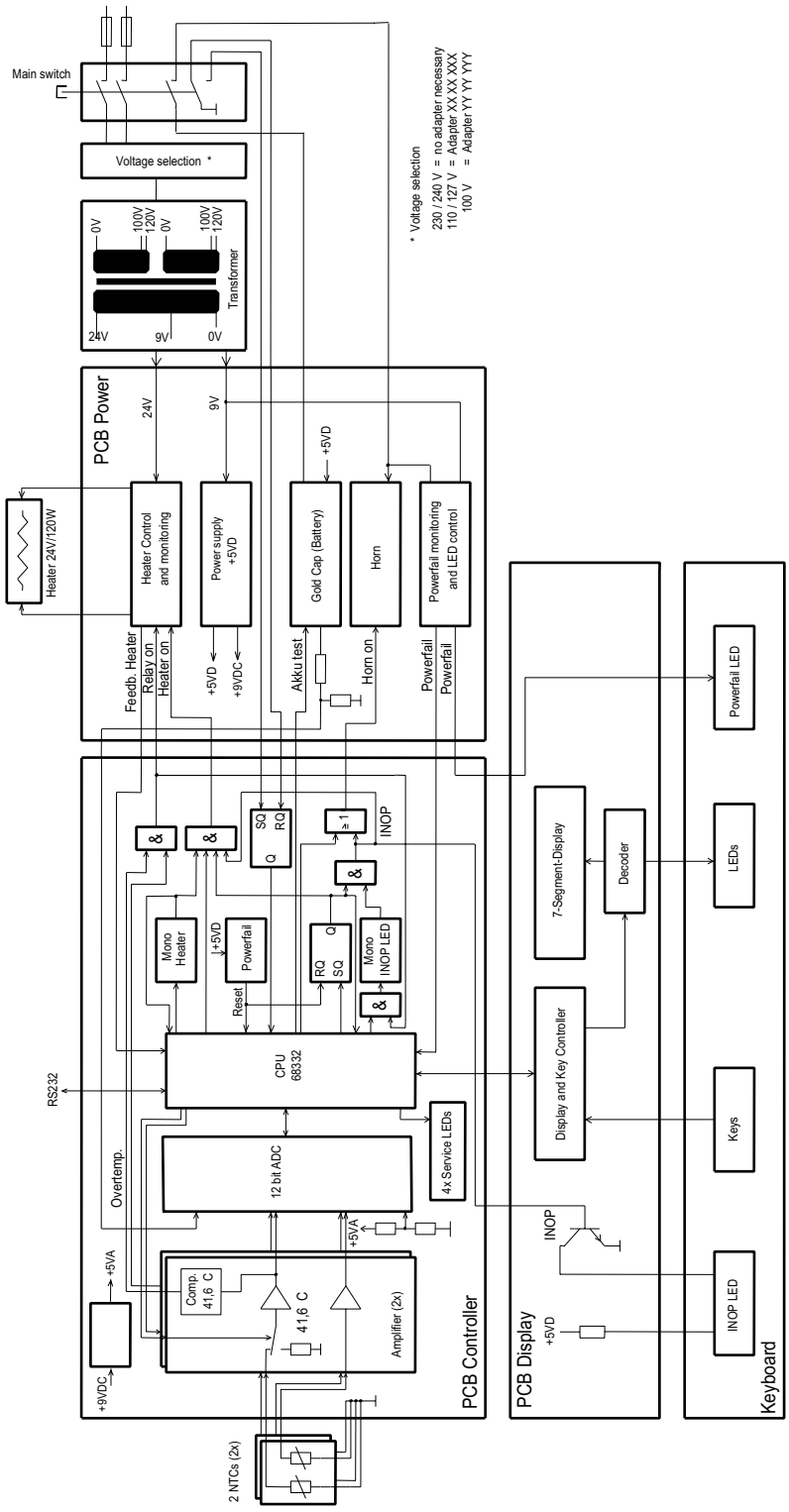

Fig. 7: Block diagram of mattress heating

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3.3.3 Power PCB

The power PCB features the following function blocks:

- Heating actuation and monitoring
- Voltage generation 5 V DC
- Actuation of horn and power failure recognition

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Heating actuation and monitoring

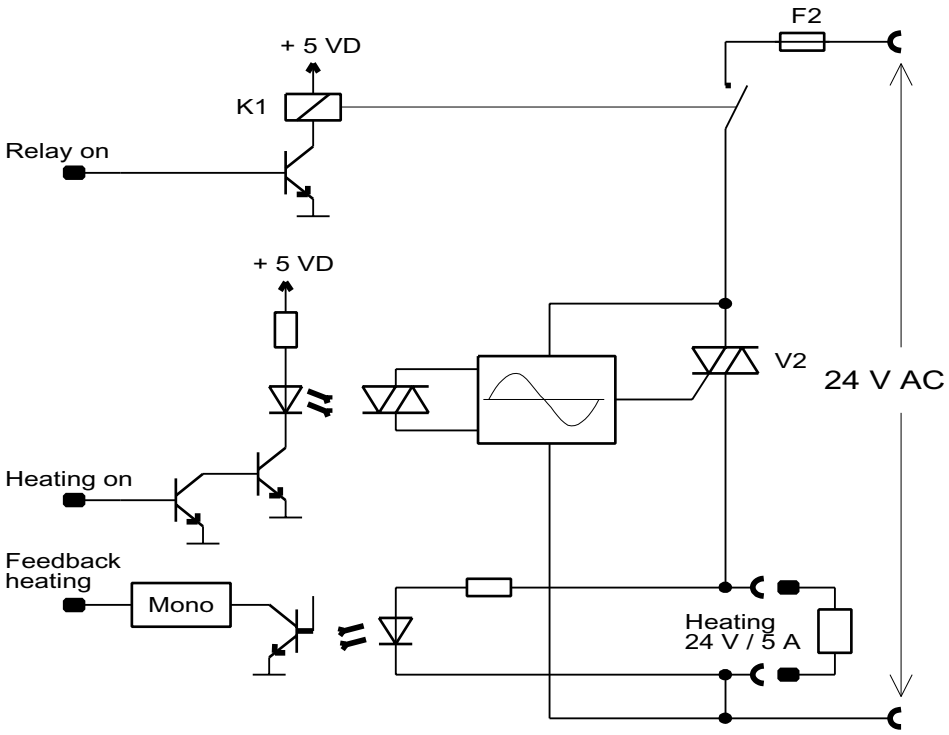

Fig. 8: Heating actuation and monitoring

- The heating runs on 24 VAC.
- The heating circuit is electrically isolated from the remainder of the electronic system
- The heating circuit is fused (F2) on the power PCB.
- The safety relay K1 can interrupt the heating circuit in the event of a fault.
- In normal operation the heating is switched by the triac VA. An upstream zero-voltage and phase-group switch ensures that the heating is only switched on in a positive AC voltage pass and switched off when negative.
- The voltage drop at the heating generates pulses by way of a parallel optocoupler which in turn actuate a monoflop. The output of the mono indicates the operating status of the heating.

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Voltage generation 5 V DC

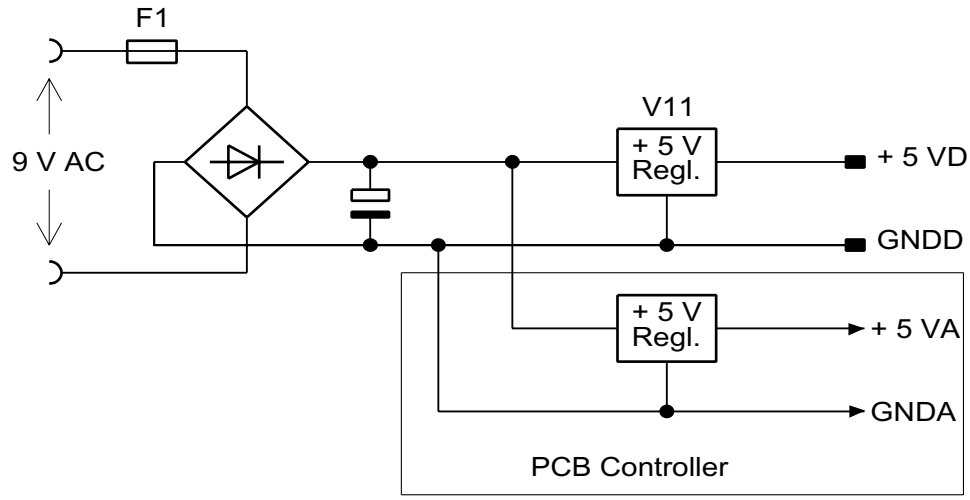

Fig. 9: Voltage generation 5 V DC

- The voltage supply for the 5 V is fused (F1) on the power PCB.
- The + 5 V digital supply voltage (+ 5 VD) is regulated on the power PCB.
- The + 5 V analog supply voltage (+ 5 VA) is regulated on the controller PCB.

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Actuation of horn and mains failure recognition

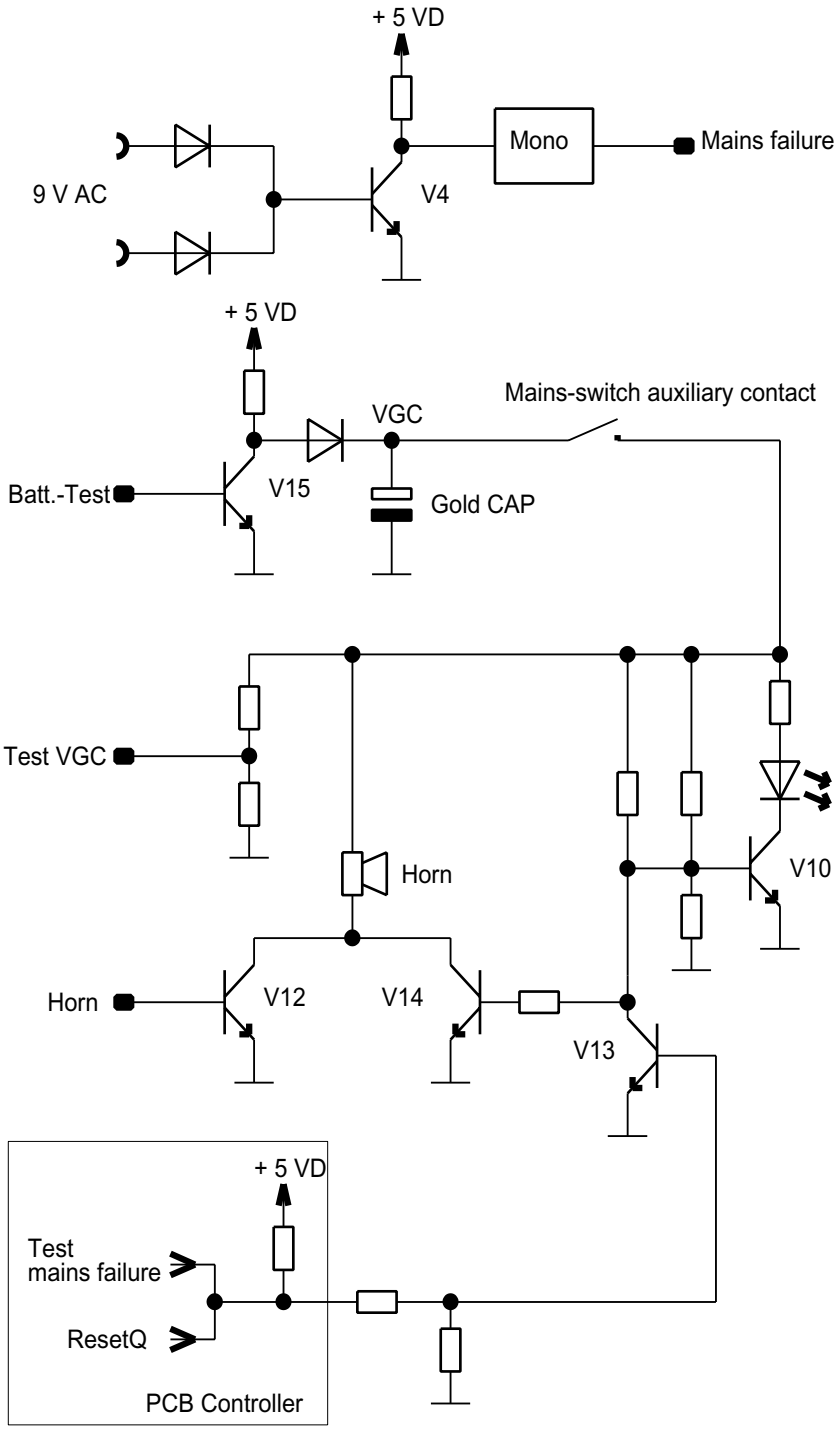

Fig. 10: Actuation of horn and mains failure recognition

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- The signal "mains failure" is generated if there are no rectified 9 VAC half-waves and the monoflop is not retriggered.
- The supply for the horn and the mains failure LED is provided by a "gold cap" 3.3 F capacitor with the voltage VGC by way of the mains-switch auxiliary contact which is made during operation.
- The voltage of the gold cap "VGC" can be measured by way of the deactivation of the charging voltage via V15 (battery test) using a voltage divider (VGC test).
- The horn is normally switched by the processor via V12.
- In the event of mains failure, actuation of the horn and mains failure LED is by way of the controller PCB using the signals "ResetQ" or "Mains failure test":

  ResetQ ==> + 5 VD is less than 4.6 V

  Mains failure test ==> Test signal from processor

Using these low-active signals the horn is actuated via V13 and V14 with the mains failure LED being actuated via V13 and V10. The mains failure LED is located on the keypad.

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3.3.4 Controller PCB

The following function blocks are located on the controller PCB:

- Processor
- Processor clock pulse generation
- RAM, EPROM
- EEPROM
- I/O lines
- LEDs
- INOP watchdogs
- Voltage monitoring
- Measured value acquisition
- Read-in of position of mains-switch auxiliary contacts

Processor

Use is made as Processor D1 of the MC68332 microcontroller. This controller is part of the 683XX Motorola family. The 68332 features the following in addition to a 32-bit CPU.

"SIM" (system integration module) with:

- Timer
- Chip-select decoder
- Bus-error decoder
- DTACK generator

2K-byte static RAM

"QSM" (Queued serial module) with:

- Asynchronous interface
- Synchronous interface

TPU (Timing processor unit), which provides time-controlled functions on 16 channels. For example pulse-duration modulation for actuation of heating.

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Processor clock pulse generation

The circuit with the quartz clock generator G1 corresponds to the recommendation given in the Motorola user's manual. This clock pulse is multiplied in the 68332 by a PPL up to a level of max. 16.67 MHz. The voltage supply for the internal PPL is provided by way of the PIN VDDSyn.

RAM, EPROM

The RAM (D3) and EPROM (D2) both feature 128K-bytes. The EPROM range can be extended with 0 ohm resistors to 512K-bytes.

EEPROM

The serial EEPROM (N9) has a memory capacity of 128-words and is used to store non-volatile data such as warm/cold-start recognition.

I/O lines

The following lines of the processor D1 are used as simple outputs for the Babytherm mattress heating.

Signal name	Pin	Significance
ANASW1	IRQ1	Signal "analog switch 1" switches analog channel 0 between sensor and reference resistance 41.6 °C: Low = Reference resistance High = Temperature sensor, resting surface
ANASW2	IRQ2	Signal "analog switch 2" switches analog channel 2 between sensor and reference resistance 41.6 °C : Low = Reference resistance High = Temperature sensor, resting surface
HUPE1Q	SIZO	Actuation, horn
LED1	DSACK1Q	Actuation, service LED 1
LED2	AVECQ	Actuation, service LED 2
LED3	RMCQ	Actuation, service LED 3
NTZAUSFTST	DSQ	Horn and mains failure LED test
TP2	TP2	Heating on (linked to AND gate with emergency stop = excess temperature comparators and watchdog)
OUTNTZ0	IRQ5	Gold cap test

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LEDs

There are four service SMD LEDs on the controller PCB:

- Reset LED (V14):
  off when processor is in "halt" or "reset" status
  lights in normal operation
- LED 1 - 3 (V1, V2, V3):
  Assigned by software depending on operating status.

INOP watchdogs

There are two watchdogs (D21, D22) on the controller PCB as safety features. Both watchdogs take the form of counters which have an independent 32.678 KHz quartz oscillator (G2) as time base.

The watchdog D21 switches off the heating if there is no retriggering. This watchdog is tested during operation.

The watchdog D22 activates the INOP LED and the horn if there is no retriggering. This watchdog is tested during operation.

Voltage monitoring

A voltage detector (V50) monitors the 5 V digital voltage. If this voltage drops below 4.6 V, the horn and INOP LED are actuated and the heating switched off independently of the processor.

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Measured value acquisition

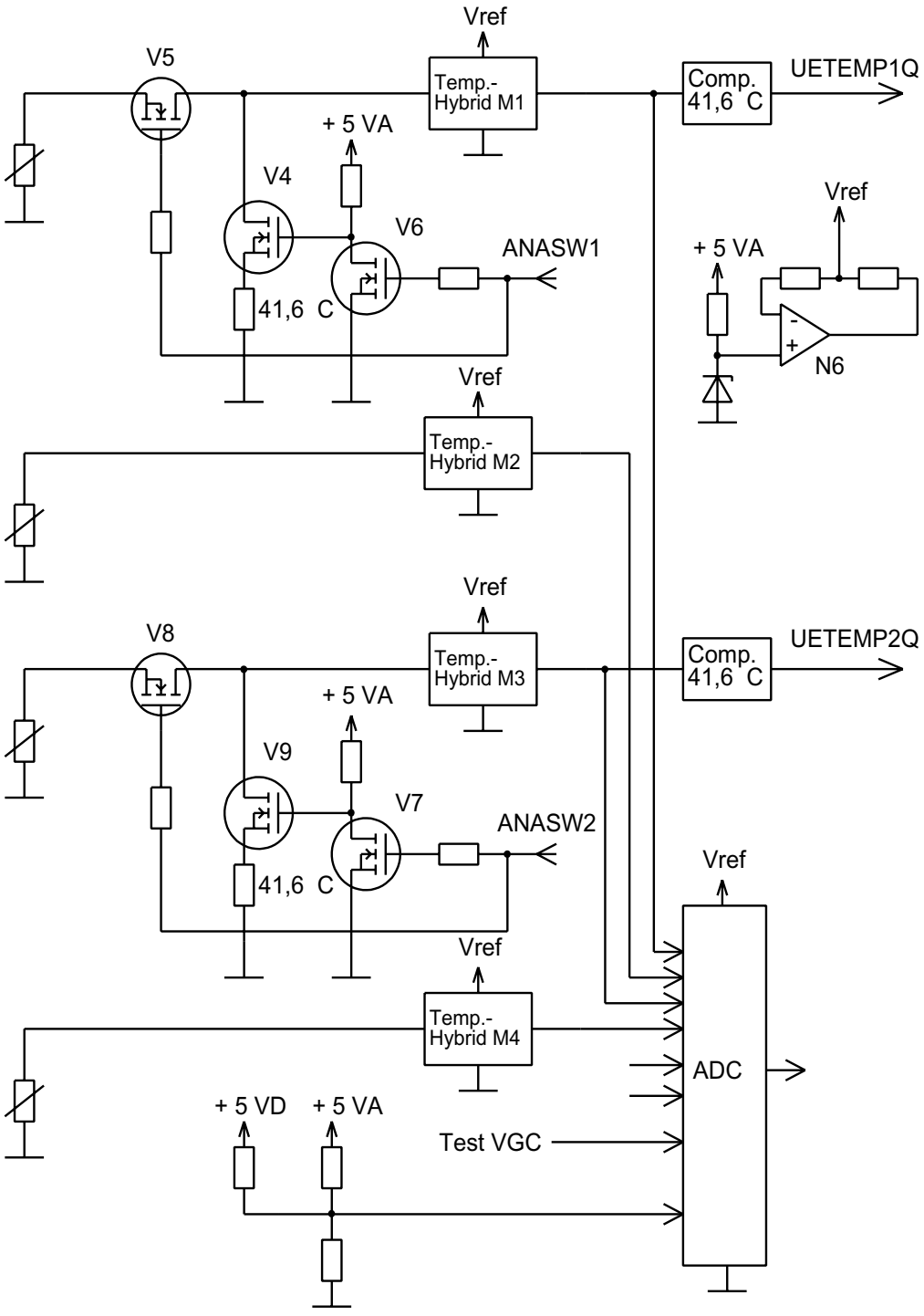

Fig. 11: Measured value acquisition

The four temperature sensors are read in on the controller PCB via four temperature hybrids and a serial 12-bit A/D converter with integrated multiplexer.

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With two temperature channels the temperature hybrids can be switched via FETS with the signals "ANASW1" and "ANASW2" by the NTCs to 41.6 °C resistors, so as to be able to test the comparators with the processor-independent heating deactivation path (excess temperature test):

ANASW1/2 = LOW ==> Reference resistance

ANASW1/2 = High ==> Measurement resistance

The outputs of the comparators are additionally read in by the processor. The temperature hybrids and the A/D converter have their own reference voltage. Furthermore, the gold cap voltage from the power PCB and a test channel can be read in by the A/D converter.

The +5 V analog voltage is generated on the controller PCB (refer also to block diagram in Voltage generation 5 V DC.

Read-in of position of mains-switch auxiliary contacts

The flip-flop D9 is used to read in the position of the mains-switch auxiliary contacts for mains failure recognition.

3.3.5 Display PCB and keypad

The display PCB has an intelligent display and keypad controller for reading in the keys and actuating the displays. All LEDs are located on the keypad. The LED "INOP" is actuated by the controller PCB and the "Mains failure" LED by the power PCB.

3.3.6 Mains switch with auxiliary contacts

The mains switch in the keypad has four switching/changeover contacts:

- 2 switching contacts for mains voltage
- 1 switching contact for mains failure alarm
- 1 changeover contact for readout of switch position for warm/cold-start recognition

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3.3.7 Transformer and mains voltage conversion

The two-chamber transformer has a minimum insulation voltage of 4 KV. By way of an adapter the mattress heating can be switched from 230/240 V to 100 V or 120 V on the primary side. **Caution: Other mains input fuses are then required.**

Note: The electrical height adjustment of Babytherm cannot be switched over.

24 V/5 A can be tapped for the heating on the secondary side. The supply voltages for the electronics are generated by way of the 9 V centre tap.

4 Radiant heater 600 W

Refer to technical documentation radiant heater RH 600.

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